



Dunedin Household Energy Study

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Kā Rakahau o Te Ao Tūroa



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Executive Summary

This qualitative study of 19 Dunedin households has provided some tentative insights into household behavior, decision-making and aspirations with regards their heating and transport choices. The households represented all four 'energy cultures' clusters and a wide demographic range. Key findings are:

1. In general, participants were aware of the environmental implications of their heating and transport choices. Many were interested in making changes (for a variety of reasons, not just environmental). Some had already made significant low-carbon changes or were planning to do so but faced barriers.
2. Most households already used low-carbon forms of heating (wood fires or heat pumps). Some used scarcely any heating. One household used coal for heating.
3. Households with floor, ceiling and wall insulation reported greater satisfaction with warmth than those that had only floor and/or ceiling insulation. There did not seem to be any consistent relationship between warmth satisfaction and the presence of double glazing.
4. Some households made conscious use of the sun for passive heating. Many were also interested in solar water heating and solar generation (PV).
5. Households were mainly reliant on the use of private cars for transport. Two used public transport on occasion. Two had electric vehicles. Public transport was scarcely used, with a major barrier being its lack of convenience.
6. Although many interviewees were interested in acquiring electric vehicles, there was concern and confusion about their environmental impacts. This appeared to be a major barrier in addition to the up-front cost barrier.
7. Household heating choices were largely driven by notions of comfort. In contrast, their transport choices were largely driven by the desire for independence and time-efficiency.
8. There was generally a greater willingness to make changes to material assets than changes to behavior. This is particularly interesting because material changes are usually far more costly than behavioural changes.
9. We estimate around 2000 households use coal for heating. Given the health and environmental impacts of coal we recommend further research on these households' motivations and barriers to change.
10. These qualitative results could inform the development of a quantitative survey of a larger proportion of the Dunedin population to provide statistically significant findings.

1. Introduction

Energy underpins most everyday household activities. Around 70% of fuel used in households is electricity, 15% gas, 13% wood, 1% solar and geothermal, and 1% fossil fuels (EECA 2020). On average, around one third of electricity used in New Zealand residences is for heating, a third for hot water, and a third for other purposes such as lighting, refrigeration, cooking and entertainment. Many households are also significant consumers of energy for transport: on average, households use one-and-a-half times as much energy for their private cars as they do within their houses: 98TJ for cars compared to 63TJ for household energy in 2016 (EECA 2020).

As a southern city, Dunedin households require more heating (and/or better insulation) to achieve comparable indoor warmth to more northern locations (Joyd et al., 2018). The Dunedin Energy Study 2017-18 (Fitzgerald 2019) showed that Dunedin households consume around 50% of the electricity, 47% of the wood fuels, 27% of the LPG, and 4% of the coal used in the city. There are no breakdowns available as to residential portion of the 7.12 PJ of petrol and diesel used in the city.

Household energy use has implications for health, wellbeing and climate change. Energy use in transport and home heating can be a significant part of people's living costs, and there is plenty of evidence that many households cannot afford to heat their houses sufficiently, and therefore suffer impaired health and wellbeing (Howden-Chapman et al., 2012; McKague et al., 2016; Lai et al., 2017; O'Sullivan et al., 2017). This is likely to be more of an issue in colder regions such as Dunedin, with a 2011 study finding that Dunedin had higher rates of fuel poverty (26-32%) compared to cities in the North Island (O'Sullivan et al., 2011).

Home heating and transport use also produce particulates that when inhaled can have serious implications for health, both indoors and out. Particulate emissions from diesel used in cars and trucks, and from coal and wood used for winter home heating

heating, can cause respiratory problems especially in locations where there is natural ponding of air (Symons et al., 2007; Pearce et al., 2006).

Household energy use also contributes to greenhouse gas emissions. Almost all vehicular transport and some home heating (coal, diesel, gas, and ~20% of electricity) is dependent on fossil fuels. With Dunedin City Council's target for zero net carbon by 2030, households will be facing the need to increasingly shift away from use of these fuels, which will mostly mean changing their heating and transport practices. For heating, it will mean moving away from coal, oil and gas, using efficient electric heating, and having low-emissions solid fuel burners for wood-based heating. For transport, it will mean shifting away from the use of private vehicles powered by diesel and petrol. This may include using electric cars and bikes and/or using active mobility (walking, cycling etc) and/or public and shared transport. Making these changes may be challenging for many households but can have financial and health benefits in the longer term.

This report draws from interviews undertaken with 19 Dunedin householders on their current heating and transport methods, and their readiness to change to lower-carbon, healthier options. Section 2 provides an overview of current knowledge about heating and transport use by Dunedin households, as well as a review of literature that can help frame our understanding of household energy behaviours. Section 3 is a thematic analysis of the household interviews. Section 4 draws conclusions and outlines future research possibilities.

2. Household Energy Use: Dunedin in the 2018 Census

2.1 Households and housing quality

Dunedin is New Zealand's fifth largest city, with a population of around 130,000 and 48,627 occupied private dwellings. Fifty-four percent of dwellings are owned or partly owned by the occupier compared to 51.3% nationally (2018 census).

Nineteen percent of dwellings in Dunedin were reported in the 2018 census as 'sometimes damp' and 2.3% as 'always damp'. Census respondents reported that mould over an A4 size was always visible in 3.4% of households, and sometimes visible in another 10.8%. These figures are not dissimilar to those reported nationally.

In the 2018 census 23.6% of Otago respondents stated that their home was "always or often" colder than they would like, while a further 28.1% reported their home was "sometimes" colder than they would like (Dunedin figures not yet available).

2.2 Heating Methods and Fuel Use

In the 2018 census, heat pumps were used in 67.8% of Dunedin households, electric heaters in 49.5%, and wood burners in 43.7%. Coal burners are used in 4.2% of households. No heating is used in 0.7% of households. Note that respondents were asked to indicate the main types of heating, so this could include several types per dwelling.

Compared to the rest of New Zealand, Dunedin has a much higher proportion of homes that have heat pumps and wood burners, and a slightly higher proportion with electric heaters, pellet fires and coal burners as their heating sources (Figure 1). There is much less use of gas for heating.

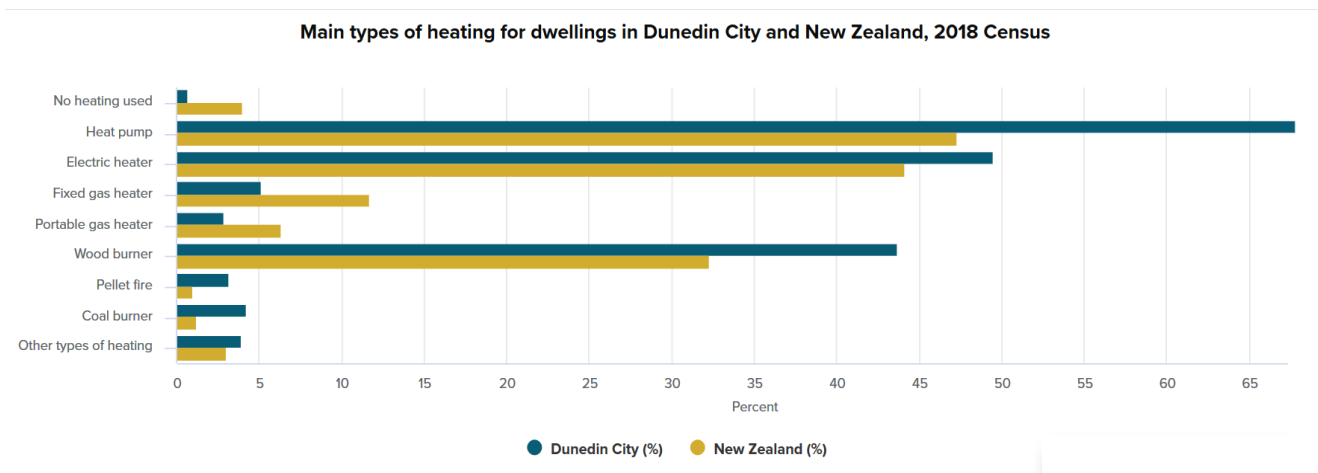


Figure 1: Main heating types for dwellings in Dunedin. Source: Statistics NZ (2020). 2018 Census Place Summaries. <https://www.stats.govt.nz/tools/2018-census-place-summaries/dunedin-city>

2.3 Transport

Census figures for 2018 show 68.6% of Dunedin residents drove a vehicle to get to work (58.5% used private vehicles, and 10.1% drove a company vehicle). Travel to work methods were generally similar to national figures apart from greater use of walking or jogging in Dunedin (9.9%). 3.4% used a bus and 2.1% used a bicycle. (Figure X)

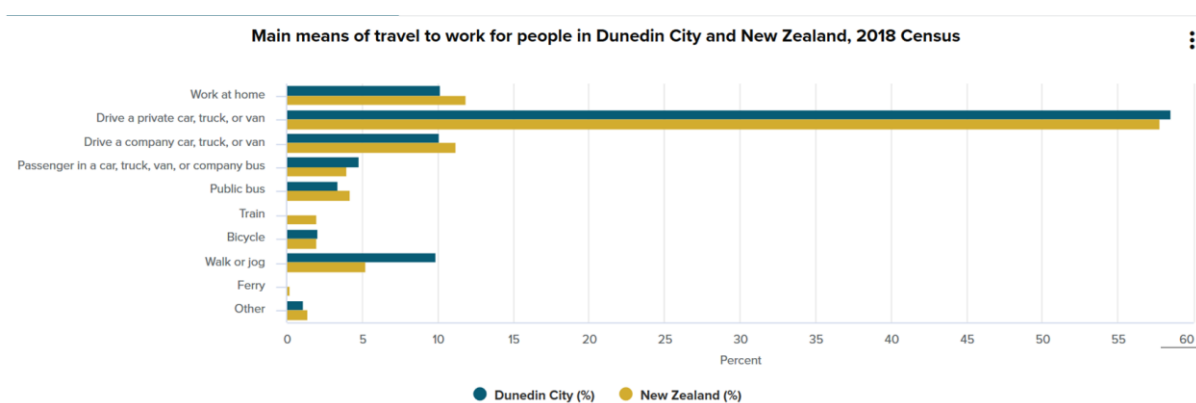


Figure 2: Main means of travel to work in Dunedin, 2018. Source: Statistics NZ (2020). 2018 Census Place Summaries. <https://www.stats.govt.nz/tools/2018-census-place-summaries/dunedin-city>

For travel to education, walking or jogging was the most common method (40.9%) followed by being a passenger (32%) and driving (11.6%). Pedestrian travel was far higher than the 20.5% across NZ generally.

There was considerably less bus use in Dunedin (3.4% school bus and 4.5% public bus) than across New Zealand as a whole (9.9% school bus and 7.1% public bus).

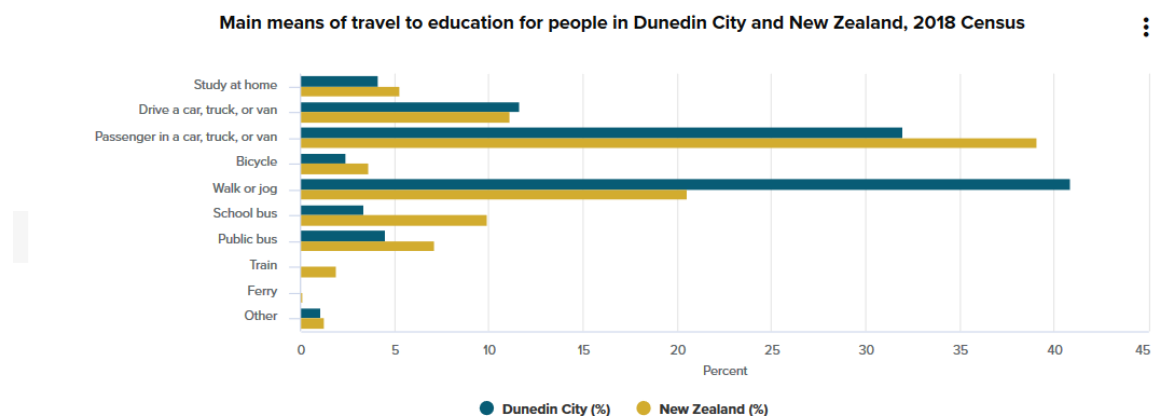


Figure 3: Main means of travel to education in Dunedin, 2018. Source: Statistics NZ (2020). 2018 Census Place Summaries. <https://www.stats.govt.nz/tools/2018-census-place-summaries/dunedin-city>

3. Energy behaviours

In this section we briefly review some key literature on household behavior and choices with regards to home heating and transport.

3.1 Home heating

Some households are unable to meet their heating needs, either due to a lack of income and affordability, or as a result of technological failures which lead to households having high energy requirements; insufficient insulation, single-glazed windows, lack of sunlight (McKague et al., 2016). However, energy usage is also a product of a wider set of social factors which influence consumer choices. Given this, it is useful to examine what motivates people's decisions with regards heating and transport, and the extent to which they have choice or not.

3.1.1 Fuel Poverty

Households in fuel poverty generally have very constrained ability to make choices as they are grappling with a limited income and often substandard housing. O'Sullivan, Howden-Chapman & Fougere (2011), define fuel poverty as the inability for a household to fulfil its energy requirements without the expenditure of over 10% of household income. According to Howden-Chapman et al. (2009), one in five New Zealand households experience fuel poverty. Sullivan, Howden-Chapman & Fougere (2011) found that Dunedin had higher rates of fuel poverty (26-32%) compared to cities in the North.

Some households may not be captured by the '10%' definition of fuel poverty because they limit their energy use due to lack of affordability. A national study by Dunedin researchers used two measures of fuel poverty and found that 35% of households had gone without power at least once because of affordability issues, or had spent more than 10% on fuel, or both. The 6.3% who had met both characteristics were the lowest income group, had more solo parents and elderly, spend more time at home, were in

older and uninsulated houses, and were more likely to be renting (Lawson & Williams, 2015).

McKague et al. (2016) found that a poor standard of home construction, insulation and heating appliances were strongly associated with the occurrence of fuel poverty and were one of the most common barriers to staying warm. This was particularly prevalent within households in rental properties, who undertook behaviours such as heating a single room, or staying in bed in order to stay comfortable.

In general, New Zealand houses are recognised as being chronically under-heated, regardless of socioeconomics (Ambrose & McCarthy, 2019). This could in part be a product of what Cupples, Guyatt and Pearce (2007) refer to as New Zealand's 'Masculine Pioneer' heritage and continuing identity. This had led to lower rates of space heating when compared to European nations (Cupples et al., 2007).

3.1.2 Thermal comfort

For households where poverty and poor housing standards are less of a constraint, thermal comfort may play a significant role in heating choices (Hanmer, Shipworth, Shipworth & Carter, 2017). Thermal comfort can be considered an occupant's preference for a certain set of temperatures, based on behaviour and activity (Nicol & Humphreys, 2002). Hanmer et al. (2017) discuss the idea of adaptive thermal comfort – and how it differs based on personal expectations. Thermal comfort can also be related to a household's daily routine, and the heating routine related to this, e.g. what level of thermal comfort is expected getting ready for work in the morning, vs. what is expected when watching television in the evening.

Thermal comfort relates not only to actual temperature but also the 'look and feel' of the heat. For example Cupples et al. (2007) discuss how New Zealanders tend to exhibit an affection for wood-burners which may be related to the radiant heat and visible glow of the fire.

3.1.3 Environmental influences in heating choices

Stern et al. (1995) argue that people's values are central to determination regarding environmental actions. This is because any information about environmental issues is interpreted and synthesised in accordance with these values. Gatersleben et al. (2002) discuss the difference between intent and impact-oriented environmental behaviours. This study found that intent oriented environmental behaviours were strongly related to the attitudes and values of the participant, while actual household energy use (impact) was more strongly related to sociodemographic factors such as household income, or household size. Household energy use is also crucially intertwined with Quality of Life (QOL) outcomes. QOL perception can play a role in propensity for change to more eco-conscious choices, or act as a barrier to change (Poortinga, Steg & Vlek, 2004).

Different factors may motivate energy use behavior in the home compared to in transport usage. Poortinga et al. (2004) found that attitudinal factors played a lesser role in transport energy choices than home energy choices. This was attributed to the multi-faceted role of transport use in maintaining QOL.

3.1.4 Energy Cultures

Another approach to investigating household energy behaviours is through studying their energy cultures (Stephenson et al., 2015; Stephenson, 2018). A household's energy culture can be understood as the interplay of their norms, practices and material items, which together give rise to energy use outcomes such as quantity of energy used, energy efficiency and levels of wellbeing.

Norms refer to beliefs, values, expectations and aspirations that affect energy-related actions and decisions. Practices are the activities and behaviours undertaken by householders that relate to energy use, such as closing curtains, setting thermostats and purchasing new appliances. Material culture includes appliances and technology within the home, as well as the building construction, insulation and glazing. These

three elements of culture are constantly interacting (for example, comfort expectations will interplay with heating practices).

Energy cultures are also shaped by influences beyond the household such as energy prices, fuel availability, regulations and media. These external influences can either reinforce existing energy cultures or promote change.

Across a population it is possible to identify clusters with similar energy cultures. Research in New Zealand on energy cultures and energy efficiency, for example, revealed four main clusters of households: 'Energy Extravagant', 'Energy Efficient', 'Energy Economic', and the 'Energy Easy' (Lawson & Williams 2012)

Energy Extravagant

This was the highest energy use cluster. Households tended to comprise of working families with school aged children. They most commonly had a dual income flow and were in the highest income bracket across the four identified clusters. They were most likely to own their own property (with a mortgage), to have the largest household size and spend the most time away from home (Stephenson et al., 2016). Their primary heating methods tend to be a heat pump and/or wood burner.

Energy Efficient

The Energy Efficient cluster was largely comprised of two person households with no dependents. They were most commonly over the age of 55 and had the second lowest average income of the four clusters. However, they were most likely to own their own home without a mortgage. They had many home improvements which improve energy efficiency e.g. double glazing and insulation, and also tended to use good energy saving practices, aside from in heating appliance use. This cluster had the highest use of wood burners.

Energy Economic

Energy Economic was the youngest and the poorest cluster. They had the highest incidence of being of working age, yet not in paid work. This may be reflective of the high number of tertiary students in the Energy Economic cluster. This group is the most likely to rent their home, and spend the least amount on household energy per year. The appliances they use tend to be inefficient, and houses under-insulated. Their most common primary heating source was portable electric heaters.

Energy Easy

This cluster was less easy to demographically stratify than the other groups. While there were a significant number of adults aged 30-34 in this category, there was also a high incidence of single-person, older households. The average annual household income was the second highest of the four clusters. Home ownership varied, with a combinations of renters, and home-owners, often debt-free. Although they often had relatively efficient appliances, their practices were less so. For example, they tend to heat more rooms, and a greater proportion of their home than average. The primary form of heating for those in the Energy Easy cluster was a heat pump and/or an electric heater.

The analysis provided by Stephenson et al. (2016) highlights the fact that any interventions to change household energy use must recognise the heterogeneity that exists across households. We cannot assume that a 'one size fits all' approach will work across all households, or even all households within a given cluster. Instead, 'The Energy Cultures framework provides insights into the complexity of forces that determine and shape energy use, and helps explain why such heterogeneity exists in the usage patterns for what is a largely standard commodity'. It gives us a platform by which to recognise the myriad of interconnected forces that drive individual's decision making when it comes to their energy choices.

3.1.5 Mobility cultures

This approach is equally applicable to investigating transport behaviours. Reducing reliance on fossil fueled cars involves interrupting a complex set of norms and practices around car ownership and use. The energy cultures framework has been used to examine 'mobility cultures' relating to car use and the uptake of alternative forms of transport (such as active or public transport) in a study of young people (under 30 years) by Hopkins and Stephenson (2016). The study highlighted how their mobility cultures (whether or not they chose to own a car, drive a car and get a drivers' licence) were shaped by external political, physical, social and financial influences as well as the person's own assets and aspirations. Interestingly, some who had purposefully chosen to use active and public/shared transport saw this as representing freedom and independence – concepts often associated with car ownership.

4. Household characteristics

The aim of the interviews with householders was to understand their behaviours and choices in the way they travel and heat their homes, and what might motivate them to change to more sustainable options. This involved conducting interviews with a range of households across Dunedin.

We had intended to interview up to 30 households, but only achieved 19 households within the timeframe set aside (November 2019 to February 2020). Recruitment was initially through University staff and students, through the Dunedin City Council's 'DCC Connect' (to draw from interested DCC staff) and the DCC's People's Panel. Most participants were recruited in this way, but we did not reach our target number and therefore we also developed posters inviting people to participate which were circulated around social service agencies and put up in several community centres. This provided a few more participants but ultimately we fell short of the desired number. This was due in large part to the research being undertaken in the lead-up to Christmas and in the holiday period after New Year, when people have other priorities. Nevertheless the households provided a wide spread over the key demographic indicators, as described below.

Ethical consent was gained for the research from the University of Otago's Ethics Committee (Ethics No. D19/354). All participants were provided with an information sheet about the research and signed the consent form.

In the results reported below, interviewees are anonymous and only identified by number, e.g. I6 is interviewee number 6.

4.1 Demographics of interviewed households

We interviewed 21 participants across 19 households between November 2019 and February 2020 (at two households visited, two people were interviewed simultaneously).

Household size ranged from one-person to five-person households (Figure 1).

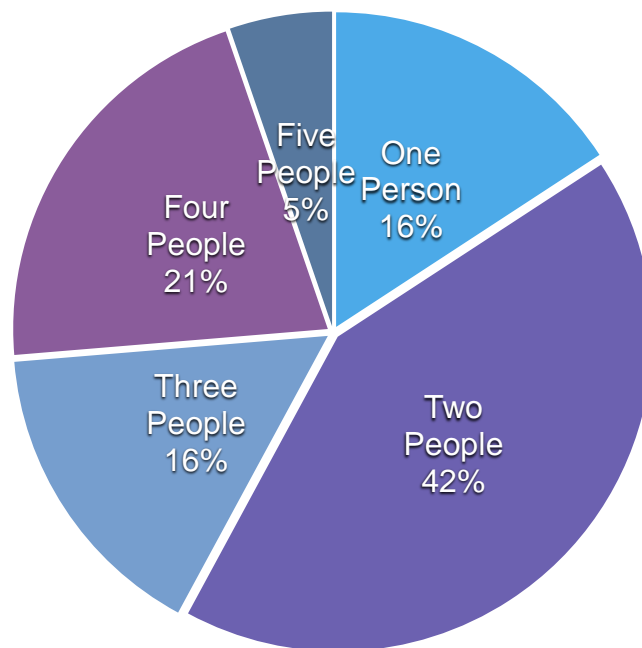


Figure 4: Household Size

Participant age was spread across all adult age brackets. Approximately half of all interviews were conducted with people aged 49 and under (10), and half with people aged 50+ (11). The distribution of interviewee age is shown in Figure 2 below.

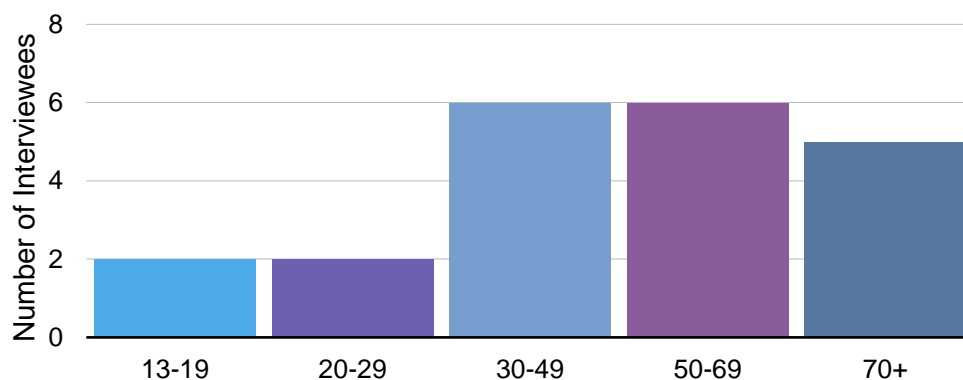


Figure 5: Interviewee Age Distribution

Approximately one quarter of households interviewed had dependent children still living at home. This includes all children under the age of 18. Of the five families interviewed, one family had one child, three families had two children, and one family had three children.

Just under one third of households interviewed had at least one retiree living at home.

A mixture of workers, students, retirees, and people not currently working were interviewed (Figures 3 and 4). Slightly more retirees were interviewed than any other group, with 6 interviews. An equal number of part time and full time workers were interviewed, at 5 apiece. This spread across workers and retirees is likely due to our flexibility in interview location. We conducted interviews at a place of the participants choosing, which saw us visit a combination of homes and workplaces.

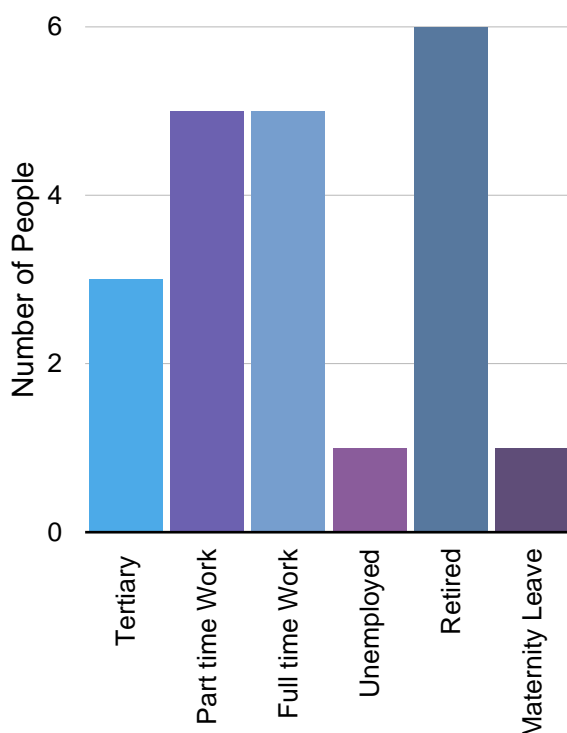


Figure 6: Main Activity Across Interviewees

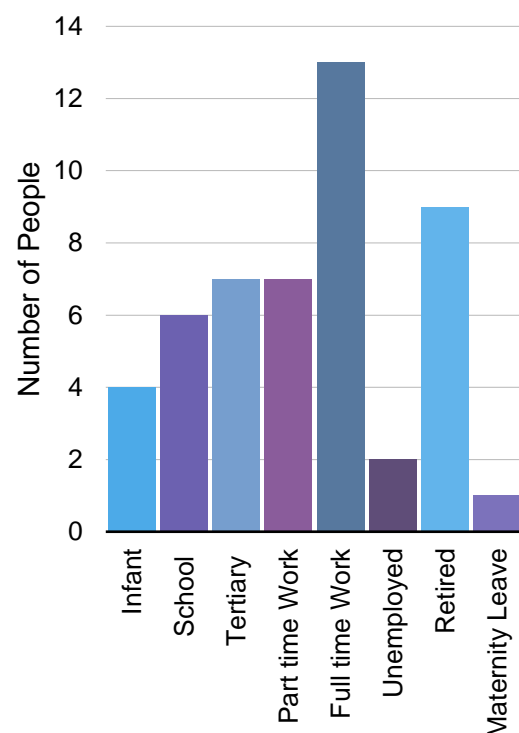


Figure 7: Main Activity Across Households

Our 19 households represented a total of 49 people. Of these people, the most common main activity was full time employment-(13) followed by retirees (9). Our households collectively had ten children, between five homes. Children ranged in age from newborns to teenage children attending high school.

We asked interviewees to indicate the combined annual household income before tax. The \$20,000-50,000 category represented the most households, at 6. This was closely followed by the \$60,000-100,000 category, which represented 5 households. Two households earned under \$20,000 annually, and two earned over \$150,000.

4.2 Energy Culture Clusters

Using the demographic data together with self-reported practices and material culture (e.g. appliances, insulation) we were able to categorise the interviewed households into the four energy culture clusters. This was another way of checking that we had a good range of household types. Factors such as household income, household size, heating and transport usage patterns, and participant age all informed the sorting into each cluster.

Figure 5 shows the distribution across the four clusters. There was a slightly higher number of households in the 'Energy Efficient' cluster, with seven in total. The other three clusters each had four households.

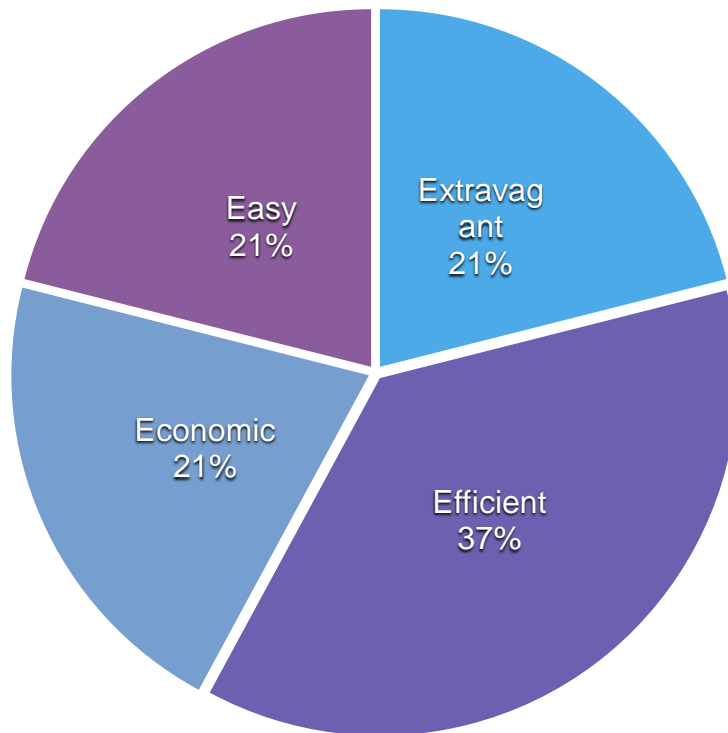


Figure 8: Energy Culture Cluster Distribution

The majority of households were easy to categorise. For example, four of the five families interviewed aligned strongly with the Energy Extravagant characteristics. This included family size, heating methodologies and practices, transport use, and home ownership patterns. Households in this cluster ranged in income from the \$60-100,000 bracket to the \$200-300,000 bracket.

Stratifying a few households was not quite as clear-cut. For example, I7 ascribed to all of the energy related practices and expenditures of the Energy Economic cluster, yet their age (50-69), employment status (working part time), and home ownership status (personally owned), better aligned with that of the Energy Easy. It was decided in all cases to cluster on the basis of energy practices, so for example I7 was considered Energy Economic.

5. Home heating results

Households were asked about their heating routines, their heating appliances and levels of insulation, the fuels used, and aspirations for change.

5.1 Thermal Routines

Daily patterns of heating use naturally differed between retirees (who were home the majority of the day), and those in full-time employment or study (who were away from home for most of the day). Those with full-time occupations tended not to use any heating prior to departure in the morning, and instead would turn heating on shortly after arrival home in the evening.

Retirees who spent a large portion of time at home were more likely to turn the heating on as soon as they got up, or their heating ran all the time. A number of this group also said that they heated either the entirety of, or the majority of their homes. This contrasted significantly with other households, who were more likely to heat only the living space – where they spent the majority of their time, or the living space and a bedroom.

Some students reported that the heating was seldom used in their homes. Some cited Electric Kiwi's free off-peak Hour of Power as the only time that the heating would be used in their flats. The Hour of Power represented a significant break with the typical energy use patterns of these households; going from using no heating appliances, to every available appliance being used concurrently for the free hour.

5.2 Heating appliances

Most of the households had access to more than one form of heating. Heating appliances reported included heat-pumps, wood-burners, diesel boilers, coal fires and electric heaters. The breakdown of heating appliances available to the households is shown below in Figures 6 and 7, which show household access to heating appliances and main household heating mode, respectively.

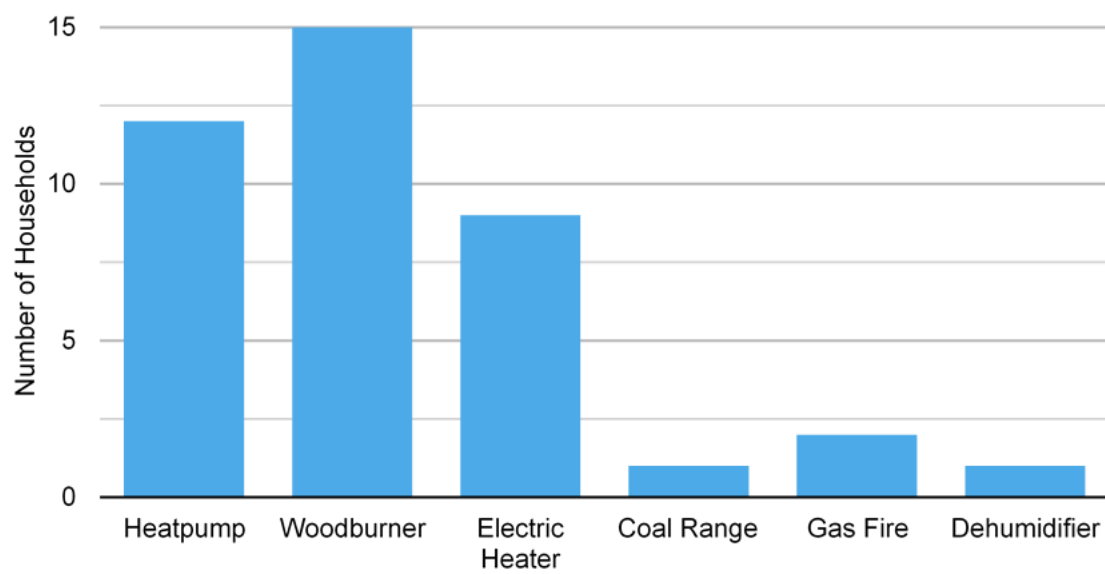


Figure 9: Household access to heating devices

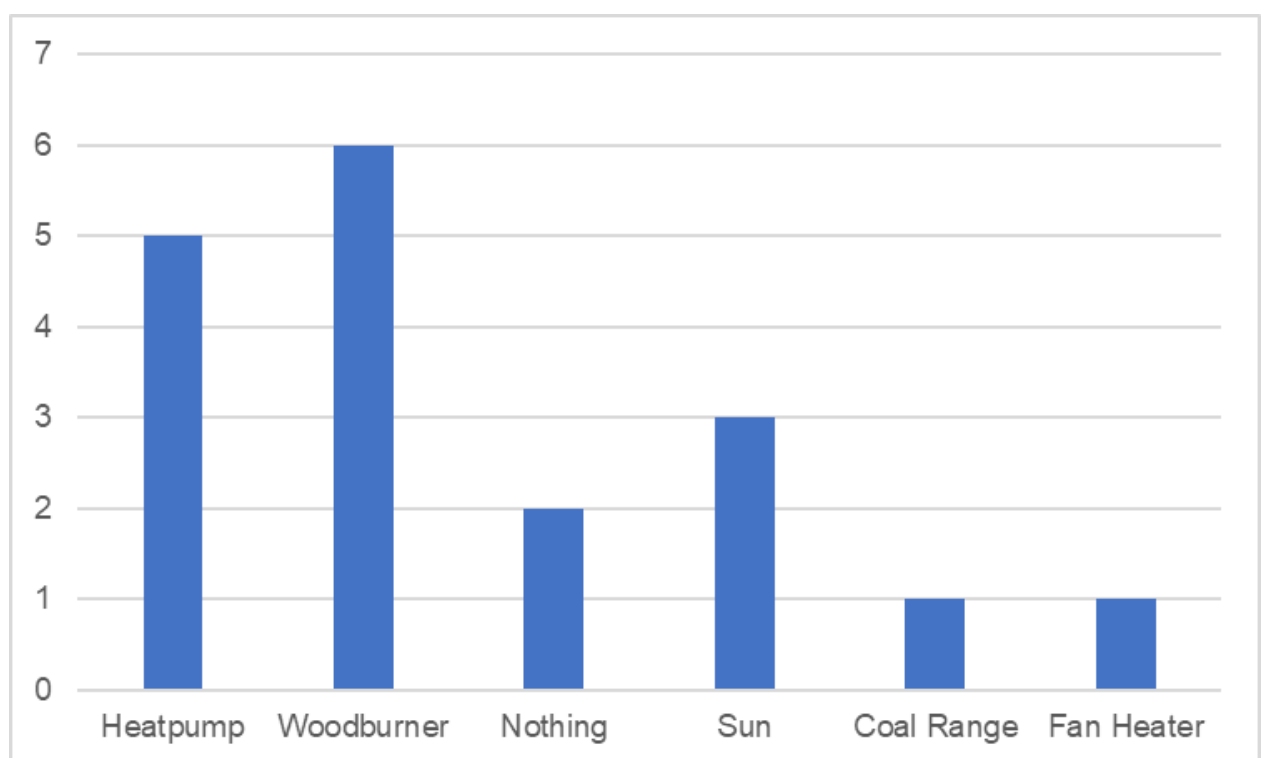


Figure 10: Household reported primary heating modes.

5.3 Woodburner Usage

One of the most commonly used heating appliances was a wood-burner. Participants highlighted a number of reasons for wood-burner usage: availability of free/cheap wood, aesthetic qualities (look and feel), and the effectiveness of a wood-burner in quickly heating a room.

Across almost all wood-burning households, access to cheap or free wood was important for at least a portion of their wood usage. Interviewees mentioned having access to wood either from their own properties (or previous properties), or properties of friends and family. This meant that households were able to reduce heating costs, and be self reliant. One household discussed how they used a woodburner due to the fact that they had wood easily available to them; *"we use wood because we have it yet. So it's not as if we're going to buy it and have it delivered."*

Availability of free or cheap wood was particularly important for a number of the retirees, which meant a wood-burner was the preferred heating option. One said that if they were not sourcing wood from their own property it would be unlikely that they would continue using their wood-burner. One participant expressed concern about the introduction of more stringent clean air standards, and the ramifications on the elderly; *"people my age and older than me had to go out and put in heat pumps and so that, before that, they'd had free firewood and then suddenly they had to pay huge power-bills."*

Participants often referred to the aesthetic qualities of a wood-burner, and the sense of warmth it creates. They considered a wood-burner to give 'better heat' than a heat-pump- despite the efficiency of a heat-pump. This comment was observed in households which used a wood-burner as either a secondary source of heating, or in combination with another source. Many participants favoured the wood-burner for its ability to effectively heat a whole room – however, many noted that the heat was not quick, and that in the meantime they either used an electric heater or a heat-pump until the fire was going.

Wood was sourced by households both commercial and privately - with three households using a combination. Two of these combination households also mentioned purchasing wood from local fundraisers - such as schools and community groups.

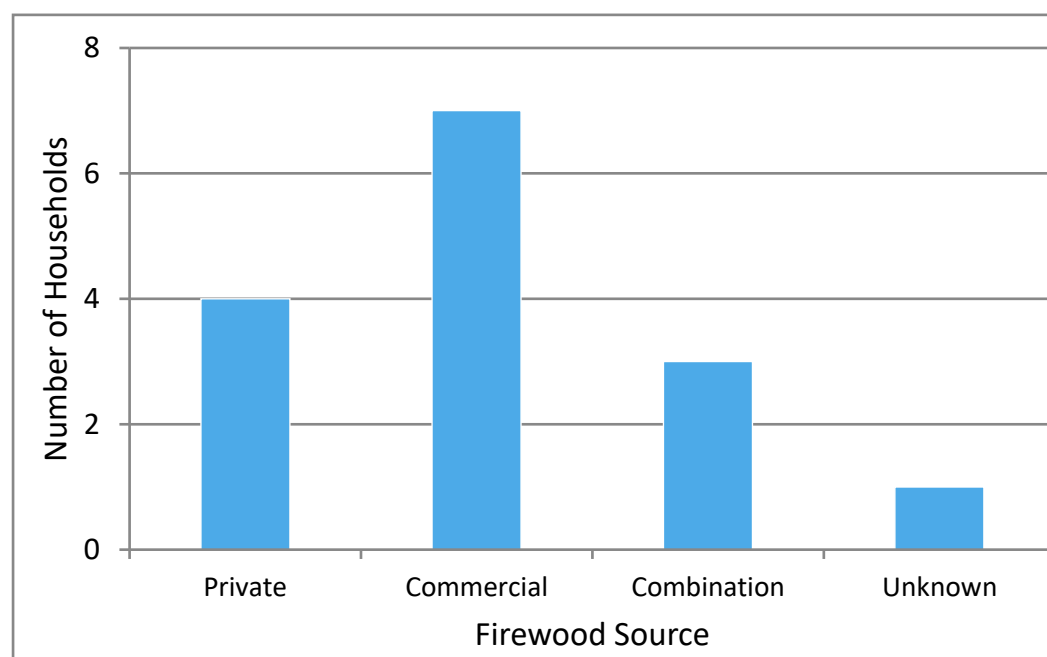


Figure 11: Source of Firewood

5.4 Sun use

Many of the interviewees talked about the importance of the sun for heating. Retirees who owned their own homes particularly cited the sun as one of the primary heating sources for their homes. These households had typically undergone extensive renovations in order to benefit from retaining the sun's warmth through the installation of double glazing and extensive insulation. Interviewees from this retired & renovated group often referred to the sun as a free source of warmth for their homes - despite the, often extensive, renovations these households had undertaken in order to retain this warmth. Three of these households considered the sun to be their main source of warmth. One of these households expressed that they had designed and

built their home with capturing the sun in mind, with extensive north-facing, double glazed windows.

Two households acknowledged the importance of the sun for heating and expressed regret that their home did not have good sun exposure. One interviewee suggested that if they purchased again in Dunedin they would purchase elsewhere with better aspect. Another said that they were considering moving in future, to a more sun-rich suburb. *"I think the change I'm going to make is that I'm going to sell my house and buy another one. So I know it sounds a bit drastic. But there's, there's things about the house around winter time, and heating, that could be better, and I think it would be better in a new house."* However, at this point in time cost was a prohibitive factor, due to pricing in these sunnier suburbs.

Within the students surveyed, the sun was rarely mentioned as a contributor to the warmth of their homes, which interviewees typically considered to be cold. These interviewees were in rental properties.

5.5 Heat pumps

Out of the 19 households surveyed, 12 had heat pumps. However these were comparatively rarely the primary source of heating in a home, with only 5 households considering the heat pump their main source of heating.

Heat pumps were typically located in the living room of the home. A number of households had heat pumps in combination with woodburners- in which case the woodburner tended to be the primary mode of heating. In these households the heat pump would often be used briefly in the mornings, before departure to work and school, and be turned off for the day. The heat pump would either not be turned on again, or turned on once the household returned until the fire was established enough to heat the living room or home.

Interviewees considered that heat pumps were easy to operate (in comparison to woodburners) and heated a room quickly. For those who used the heat pump as their main source of heating this ease of use and speed were the reasons supplied for heat pump usage. Several respondents recognised the efficiency of a heat pump, but despite this did not favour them as their appliance of choice, with one interviewer saying *"In principle I really like heat-pumps but in practice I don't."* These interviewees who had heat pumps, but used them only infrequently, often referred to the cozy atmosphere provided by fireplaces, and the absence of this cozy atmosphere with heat pump use. One interviewed household currently used a heat pump as their main source of heating, but expressed a desire for a woodburner for these reasons.

5.6 Coal use

Only one household currently used coal for heating, and one had recently transitioned away from using coal.

Several of the interviewees mentioned that coal combustion was detrimental to the environment. Alongside this, they mentioned other factors such as the impact of coal smoke on health, and the unpleasant odour produced by a coal fire. Out of 19 households, when asked about their environmental choices, four interviewees cited a decision not to use coal as a key eco-friendly choice, and a way of aligning their environmental views with their heating choices. One of these four households mentioned using coal in the past (around 10 years ago), and making a deliberate choice to stop this. Another household expressed strong aversion to coal use. Although this interviewee did not express a refusal to use coal as a key environmental decision they were frustrated by their neighbours' continued use of coal, and the resulting odour - *"two of my neighbours on - on this side of me burn coal, which pisses me off. I've actually gone and talked to the people that owned the house previous to the ones that own it now. And said 'you gotta stop burning coal, because it's coming straight into my house.'"* One further household had stopped using coal recently; although this household recognised the environmental impact of coal-burning, environmental reasons were not the basis of this decision.

The household who had moved away from coal in 2019 did so for health reasons, rather than environmental aspirations: *"We used to burn coal, until - we know that's bad for the environment, but it was cheap, and it would keep your house warm all night, and it would keep the whole house warm. And we, we stopped that last year, because our ceilings were getting black, we were worried about what our lungs were like."* In this case, the interviewee did suggest that reduced environmental impact was a co-benefit of moving away from coal - although it was not the primary motivator. Prior to ceasing coal usage the household had previously tried to cut down on coal use by burning wood during the day, and using coal at night - in order to keep the house warm for an extended period.

The household who currently used coal had a coal range with a wetback which ran throughout the entire year. The house was over 100 years old and poorly insulated with single glazing. They said that it was hard to keep warm without spending an extortionate amount of money. The financial aspect was therefore a significant barrier in changing. Interestingly this interviewee had significant environmental aspirations, and recognised that their current heating choices did not align with these. Despite this, the interviewee did not see a more effective option for heating their home. They expressed concern about the environmental impact and efficiency of electric forms of heating. They felt that heat pumps did not work effectively in Dunedin, and led to overheating of the home: *"Plus, I was also really disappointed in the whole heat pump ethos. Where heat pumps were touted as being be all and end all. But in Dunedin they don't actually work. You're actually paying - you're basically just running a big fan heater into your home and producing what in my mind of too much heat a lot of the time."* (I18)

5.7 Non-consumptive warmth strategies

Individuals and households also use strategies to keep warm that don't involve space heating. Personal non-consumptive strategies that were reported included putting on

multiple layers of clothing, using blankets, hot water bottles, thick socks, and slippers. As one participant explained:

"When we get home we would put on, we would change out of our clothes into sweatpants. I have ugg boots that I wear as slippers around the house. Husband will put on his wool socks, and put on at least two jumpers, and I have those little gloves, the fingerless gloves with the fingertips cut out." (I2)

Personal non-consumptive warmth strategies were common, with 14 interviewees mentioning that their households use such methods as alternatives to energy-fuelled heat sources.

Household-level non-consumptive strategies were also popular. Eighteen of the 19 households interviewed used various methods to retain warmth within the house. This included closing curtains at night (17), using draught stoppers (5), selectively closing interior doors to control heat distribution (2), and installing plastic film over windows to replicate the benefits of double glazing (3). *"There's plastic over the windows because of course they're still single pane. So they did the big clear plastic sheets over the window you shrink up with the hairdryer" (I2).*

Households had different justifications for some of the non-consumptive strategies. Notably, of the 17 households that made a practice of closing the curtains in the evening, several households did so merely for aesthetic value, or perceived 'coziness', as opposed to a warmth strategy. Two households explicitly explained this in their discussion, saying:

[Speaker 1] "...to see a so big area of black glass at night is less, less pleasant." [Speaker 2] "...it's psychological, rather than from energy points of view." [Speaker 1] "Oh I agree, I don't think the curtains are you are adding a great deal to the heat retention." (I8)

"Yeah it's for atmosphere. Like, I'd say coziness, yeah." (I14)

Given that both of these houses were double glazed, with occupants expressing satisfaction in warmth levels, it is interesting to consider how aesthetic value may play

into decisions around energy use and consumption. This was also found to be prevalent when identifying primary reasons for fire use.

5.8 Perceptions of warmth

The importance of comfort also related to questions around satisfaction with household warmth. This was asked in the form of 'Is your house as warm as you would like?'

Ten of the 19 households expressed dissatisfaction with the current level of warmth in their house. This ranged from significant dissatisfaction with the status quo; *"No, definitely not. No, it's not. Cold air comes through. I don't think it's a healthy house"* (I3), to a wish for increased warmth on top of what was already present; *"It's not always as warm as I'd like to be"* (I6), and *"I mean, ideally it would be lovely to walk into the hallways and them be heated possibly as well"* (I1). Nine households were satisfied with the current levels of warmth in their home.

The 9 households that were happy with their level of warmth all had insulation in all or most of their ceilings, floors and walls. In contrast, of the 10 households who described their homes as cold (or not as warm as they would like) 2 had only ceiling insulation, 3 had only ceiling and floor insulation, and the rest were unsure whether and/or where they had insulation.

However there did not seem to be any consistent relationship between household warmth satisfaction, and the presence of double glazing. Of the 15 households that were asked about double glazing, nine currently had these windows in their house. Six were happy with their current level of warmth, and three were not. Of the six houses who were not double glazed, three were satisfied with their current level of heat, and three were dissatisfied. Only one of the non-double glazed households had made any window-based improvements; having installed plastic film over the windows in an attempt to replicate the effect of double glazing. They were also dissatisfied with their warmth levels.

5.9 Motivations relating to heating

We asked participants what factors were important to them when considering how they heated their home.

A range of responses were received, with the most common response placing comfort as top priority. Nine households, or just under half of those interviewed identified comfort as the most important factor in their heating choices. Examples of how this was expressed include: *“Comfort, whatever comfort means to me is the most important”* (I12). *“Comfort's key man”* (I11). *“Comfort before cost. If we need to put a log of wood on or another log on, it's just something we do”* (I16).

The environment was the second most common key motivator, with four households deeming it a priority.

“We probably consider the environmental impacts the most. So like the carbon intensity of what we're doing and the time, the timeline of when it would be put back in the carbon cycle.” (I2)

“Because the most important thing to me is to have, you know, low emissions and have a sustainable lifestyle. But we've, we really struggle with energy. We have a lot of ideals that we really love to meet.” (I18)

Four households had interrelated factors that were mutually important. Two households saw health and comfort as being equally important. Both of these households had young children, and related their factors directly to them; *“Just being warm. And the kids being healthy”* (I19). Two households deemed various multiple factors as being equally important. The interconnected nature of these factors is best summarised by I9, who explained their position as including cost, efficiency, comfort and health:

“I think, to be quite honest, they all tie in together. Because I think you can heat your house at a reasonable price as long as you've got a house that doesn't leak heat. And that makes it

comfortable, makes it drier, so we don't have condensation running down windows or any of that sort of thing, so it's a dry environment. So that's healthy that way." (I9)

5.10 More Sustainable Forms of Heating

The interviews also sought to identify interest in, and motivations for, changes to more sustainable forms of household heating. This was specifically asked by way of Q10, using prompts: 'Are you interested in pursuing more energy efficient or environmentally conscious forms of heating? (A) What forms have you considered (if any)? (B) What are your barriers to doing so?'

Twelve households said they wished to move towards more sustainable forms of heating at some stage in the future, and gave an example of their preferred option. Five households expressed an interest in transitioning to solar at some stage. This included both solar water heating and photovoltaic panels. While some households specified what form of solar energy they aspired to, others just referred to solar energy generally: *"I mean obviously solar would be great..."* (I6). *"We had looked at solar..."* (I1).

Three households were interested in moving towards a passive house system.

Each of the following changes were mentioned by one household respectively; upgraded insulation, ceramic wood burner, double glazing, and hydroelectric power.

Cost was the most commonly expressed barrier to these upgrades, by 10 of the households. The other two households were renters, and this rental status was the primary barrier.

For houses that had considered the installation of solar-based systems, cost was referenced both in terms of upfront cost and expected payback time. Examples include:

"the payback... it doesn't stack up." (I1)

"I've never really explored it any further than that because the cost. Putting the environmental costs aside, the cost of installing versus the cost of the benefit, like it doesn't... the capital expense. Where, I don't think you'd really regain the costs, maybe over 20 years or 30 years..." (I17)

"but we've got no plans to do that at this stage, just because we've got busy lives and the kids are costing us tons of money. We can't afford it." (I6)

Passive housing is quite rare in New Zealand so it was interesting that 3 respondents knew enough about it to express interest in moving to a passive house system.

It is notable that the responses to this question were largely not about more sustainable heating, possibly because most already use low-carbon heating systems (heat pumps and wood burners)¹. Their aspirations for change were a mix of improving heat retention, solar use, water heating, and renewable electricity generation. Only one reference was to an actual change to a different heating appliance.

¹ Based on the emissions factors supplied in the Ministry for the Environment's *Guidance for Voluntary Greenhouse Gas Reporting (2016)* wood and electricity have the lowest rate of GHG emissions compared to other heating fuels.

6. Transport

Households were asked about what vehicles they owned, and their interest in using lower-carbon forms of transport such as electric vehicles (EVs), public transport, active transport and ridesharing. Barriers to change were also explored.

6.1 Interest in electric vehicles

Nine of the households expressed a positive interest in acquiring an EV, and nine households did not. Of the two households who already owned an EV, one (I14), had upgraded their only motor vehicle, and the other (I17), expressed an interest in upgrading one of their other vehicles: *"...ideally we would still have a van, but it would be an electric van. We will sell the petrol vehicle."* (I17). As such, 18 households formed the sample of this group.

The households that expressed a willingness to move towards EVs ranged from those with definite plans for their next vehicle upgrade, to those who hoped to be able to transition in the future. One household was also interest in hybrid vehicles. Examples of how this interest was expressed are:

"...unless the car really dies in the next 12 months and then we will probably look at getting a secondhand electric car... Electric is the next... The next step." (I2)

"I would absolutely love to get an EV and that's sort of on the cards for the next vehicle that we buy... we will definitely replace one of our cars with an EV at some point." (I6)

We have been looking at electric and the prices of electric cars for the next one. Or what is it called when you have both? Dual?"... "our next one will be either electric or hybrid." (I19)

The main barrier to moving towards an EV was cost. There was hesitation around the cost outlay required to purchase an EV, as well as critique of the general cost of the vehicles.

"And so, personally, I think they're just fine for rich people who want to feel good about themselves and they cost so much money, but ... not really for me." (I7)

"All they're doing is just- open up another coal fired power station. Just so, so someone can have an electric car. What's the sense in that. I think it's a fantastic marketing ploy that they've done to suck people into buying the bloody things. And they're expensive." (I9)

"You know, I mean I'd love to have an electric car for example. But just can't afford it. Yeah. So it's the same with, we'd love to use electricity. But it's just really expensive." (I18)

For some households, although there was a strong interest in EVs they also had some concerns about some of the rare earth metals used in the vehicles, expressed as:

"When I change my car I will look at an electric vehicle, but there are problems. There are problems, and I'm not environmentally convinced that a good thing. The, the rare earths are rare. The mining for that is dubious." (I12)

"Our goal is to get an electric car ... well we don't really really understand like the whole problem about lithium and all of that kind of the battery thing. You know, we haven't really felt that there's a great deal of transparency in the industry." (I18)

Concerns around EV sustainability, source material, and end of life, were also a driving factor for many of the households who were currently not considering purchasing an EV. Hesitations, or outright concerns, were specified as:

"We have talked about, but we just don't think they're real answer yet either. And that would mean certainly if there was something out that, you know, they could actually run that didn't have the aspect of getting rid of, lots of dead batteries..." (I1)

"I do know that the bat- the lithium is a major issue in the mining of it in the end of its life. And so, personally, I think they're just fine for rich people who want to feel good about themselves and they cost so much money." (I7)

"I reckon, electric is a joke because all you're doing is you're transferring the emissions to someone else to generate the power ... I think it's a fantastic marketing ploy that they've done to suck people into buying the bloody things. And they're expensive. And what do you do with the batteries at the end, they're real nasty in the- And a lot of the chemicals and elements that are in them, to get them out of the ground and that, you know, I just think it's a short term gimmick, to be quite honest." (I9)

"The electrics aren't at this stage, practical." (I16)

The interviews suggest that public knowledge and understanding of EVs is varied. Some are strong believers in their environmental credentials (compared to fossil-fueled cars) and are aiming to integrate them into their future household transport methods. Others are interested but are hesitant as to whether or not they are actually as environmentally friendly as they are made out to be. Others again are outright skeptical of their environmental benefits.

This suggests that there is a lot of confusing information about the environmental impacts of EVs, particularly around the use of rare earth metals and the lifetime and disposal of batteries. These are legitimate questions, and need to be addressed and clarified for some people to feel comfortable about EVs. Another issue is about whether the greenhouse gas emissions are much less over the lifetime of the car, and this may be based on a lack of understanding of the difference between New Zealand's low-carbon electricity generation compared to other countries. Given this, it seems likely that the uptake within households is likely to be largely variable if knowledge remains at status quo.

6.2 Ownership and use of electric vehicles

Two households owned electric vehicles (EVs) at the time of interviewing. I14 was a two person household with a single motor vehicle, this being an EV. I17 was a four person household with two young children. They owned three motor vehicles; one petrol car, one electric vehicle, and a diesel truck.

Both expressed satisfaction with their decision to transition to electricity as a fuel source. One participant detailed his satisfaction as follows:

"It's a really nice car to drive. Nicer than a, than a petrol car. 'Cos it's quiet, it's smoother, and it goes like shit. And yeah like it - when it dies or whatever, which hopefully it won't - then I'd go electric again." (I14)

Interestingly, both households who owned EVs recognised that their willingness to use their vehicle had increased since their transition. A greater amount of time was spent driving, and more trips were undertaken. Both reasoned that this was due to lessened feelings of guilt, compared to using a petrol vehicle. Each household's reasoning is given below:

"Actually since we've got electric we use it more than we would a petrol car." (I14)

"Yeah, well you know, makes you feel better. Eases your conscience. Even though it's like, it's still a vehicle and it's not perfect." (I14)

"...we don't try and minimize our trips in the electric car, and I definitely would have when we had the petrol car. So I do more traveling now by car, now that we've got the electric car." (I17)

If this is a more widespread experience, it is important to consider whether an increase in EV ownership, while reducing emissions, may increase other vehicle related stresses to inner city Dunedin. For example, increased willingness to drive, and increased short trips, may see a rise in traffic congestion and pressure on the infrastructure.

6.3 Public transport

Overall, households had a low use of public transport. Only two out of the nineteen households interviewed reported using public transport with any regularity. None of the households interviewed considered public transport to be their main form of transport. The two households who used it regularly used it in combination with

forms of active transport - walking or cycling, depending on the structure of their day, weather and other factors. *"So I would use my car, maybe once or twice- twice a week at the most. The rest of the time I would walk or- walk, run or take the bus. "* For these two households (I11 and I13) using the bus appeared to be a part of a wider choice to reduce car travel: with interviewee 13 saying *"I really don't like driving my car. Also for a number of reasons. Um, I find it stressful. And then I don't like being in the car. And also, the carbon makes me feel horrible. And, yeah, so all of those things, and I guess the bus is just really handy."*

Six households never used the bus service. For a number of these households this was a result of living in outlying suburbs or on the Peninsula, and their nearest bus stop was a significant distance from their home. Many felt that travelling by public transport would add significant time to their commutes, involving the switching of buses during their trip. This inconvenience, and time difference were significant factors which deterred them from using public transport. One older interviewee reported never having used a bus: *"I have never been on a bus in my life. Now wouldn't even know- I know that you get your card and you can get some 'go card' that lets you on for free and all this sort of stuff. But I can't- I haven't come to grips with [it]" (I9).*

Out of the households interviewed, 9 were retirees. Despite the availability of free public transport at off-peak hours for super gold card holders, retirees interviewed reported very little public transport use. Several stated that the changes made to Dunedin's bus service had made public transport inaccessible for them. One interviewee stated that due to health issues she was unable to walk from the Bus Hub to the Octagon, or George Street; the bus system changes had made her dependent on her car for transport, or at times when she was unable to drive, dependent on others; *"I cannot walk from either Dowling Street, or the bus hub into the octagon area and do my stuff that I need to do. It's not, I'm not capable of doing it...If I want to go say to the Octagon area and the Meridian Mall there's now no buses along George Street. So, I've given up using the bus. I'm on the bus route - we chose to live here, because we were on the best bus route in*

town, with a bus stop opposite!" For these interviewees, continuing to drive was a crucial part of maintaining independence.

Some interviewees saw bus use as a waste of time, or as generally inefficient: with I9 saying *"how do I do the things like I just spoke about. How do I do that in a bus. Bloody impossible. I can go to the dentist, and then come back again. But how do I do all these other things?"* Or I12 - *"so if you want to go into town for, say, a 10 o'clock appointment or however, you could just do it, and catching the bus, half an hour earlier, just. Then, when they put the bus hub in, they change the timetable again. So now, I have to catch the bus 40 minutes before. Well, it just starts to get completely ridiculous. Because, because then the 40 minutes is because you've got to walk further from the bus hub and the bus takes longer."*

Several households recognised that using public transport would be an option for them, but they did not see any benefits, or felt it would disadvantage them - either financially, or in terms of their time. For example, Interviewee 19 said: *"at the moment, paying the amount that you're paying, I thought I can actually drive and park cheaper than this. Why would I wait for a bus?"*

A number of households suggested that using public transport was something that they would potentially be willing to use, if infrastructure improved, or if they were unable to commute in other ways. This gap between 'theoretical willingness' and actual behaviours is hard to bridge, and may be related to perceptions about quality of life. Dunedin residents may be more willing to make changes in terms of home heating technology - where they feel their quality of life will benefit - than changing their transport, where QOL impacts are perceived as negative. To encourage a move to public transport this suggests that improving its convenience will be critical.

6.4 Active transport

Interviewees who were reducing car travel and using alternative transport were typically motivated by factors other than environmental reasons, such as enjoyment, health, fitness, and cost.

Two interviewees considered cycling to be their sole, most common mode of transport. Interviewee 13 discussed their personal reasons for using cycling as their most common form of transport, saying *"I just prefer it because it's healthier. I feel way freer. It's nicer to be out in the air. I feel good about it because it's no carbon."*

Although environmental impact was a factor in using active transport it was part of a wider values schema, with Interviewee 13 stating that around 60-70% of their motivation for cycling was to reduce carbon emissions. Interviewee 15 also had a dual motive for cycling; exercise and carbon guilt. Interviewees 17 also commuted using a mix of cycling and an electric vehicle. Their reasoning for cycling was also a combination; health, environment and cost. However, despite this combination of regularly using two low-carbon forms of transportation this household did not feel as though environmental issues played a big role in the way they thought about their travel - *"it's a happy coincidence that we can feel good that we're doing, that we're being more sustainable by having the electric car."*

All of the three households who cycled appeared to be very committed to cycling, with a genuine passion for it. One household highlighted that although cycling infrastructure did not serve as a barrier to them now, they felt that accessibility still played an important role in making sustainable transport choices. *"It's not so much a barrier for us now. But, especially if we're looking at changing our lifestyles and the way we do things, if everyone else is being more sustainable it's easier for us to also be more sustainable."*

One interviewee used to regularly cycle, but had since given it up due to being repeatedly hit by cars - *"I kept biking for a while afterwards. And then someone says, 'You know, you don't have to do that.' So we thought how we could rearrange our transport options and, yeah. Thought yeah, nah, stuff it. If there was a bike path, an off road bike path all the way, not just the painted line, I'd use it."* However, this interviewee highlighted that cycling

was still their preferred means of transport, and would like to cycle in future, but they currently felt unsafe cycling in Dunedin.

6.5 Ridesharing

Willingness to use ridesharing methods was gauged with the question: What are your thoughts on, and willingness to use, ridesharing methods? (e.g. Uber, carpooling, rideshare apps such as Smart Travel Otago). Though not specifically framed as a personal question as opposed to a wider household question, most participants framed their answer in terms of their own willingness.

Participants talked about two forms of ridesharing. One was *formal rideshare networks* such as Uber and Smart Travel Otago. These are often technologically based, and tend to involve travelling with unfamiliar people. The other was *informal rideshare networks* such as carpooling with colleagues and shared travel networks - people familiar to the traveller.

Willingness to rideshare, for some, was contingent on whether or not this occurred through a *formal* or *informal* network. One example of this was I19, who noted that: “Even though, as good as people do it ... I wouldn't really jump in the car [unless] I knew ... the people I was with.” However, if provided with a familiar informal network, they were willing to rideshare, so long as “I knew the people yeah like so if it was a whole group from school.” They then elaborated that this informal network was already active, as “we do it for sports actually, for my son's sports. I'm like, I'll pick up three kids and take them.”

Eleven of the 19 households either actively did use, or were interested in using, ridesharing networks. The quotes include both informal and formal rideshare willingness.

“Yeah, I think it's great. Yeah. I think that this definitely should be something that's focused on or improved.” (I5)

"I just like, lime scooters are awesome. Uber is awesome." (I11)

"If I knew someone and people were willing to ride share, you know, on a personal basis, I would do it." (I14)

"[name] may drop me off at work so we go down to one car to go to work." (I16)

Eight people expressed hesitations about ridesharing. Their concerns included efficiency, convenience, personal safety, and the added complexity of incorporating it into one's transport routine. Explanations include:

"That's not really something I think about because I don't actually find it convenient." (I1)

"It's something to be considered but it's not a necessity to do, is it- as things stand. Now, you know, if you've got petrol rationing or something you know, for some reason - a war on somewhere. You might be obliged to do that." (I8)

"I wouldn't commit myself to it now." (I10)

"Well they all require you to put on your location and stuff, and I'm not prepared to do that. Have some stranger rock up, to pick me up, who I don't know who they are." (I14)

"Whenever I think about those the obstacle is the lack of routine and the need to commit yourself to some particular- being in a particular place at a particular time. So, I like being free to go when and where I like." (I15)

People were also hesitant about informal carpooling networks because they were concerned about letting other people down (e.g. being late) either as the driver or the passenger. For example:

"I would be nervous to have other people relying on me. So I suppose being in this kind of job where you don't have to study, you don't have to... You just aren't tied to that like nine to five schedule." (I2)

"... you know, 'oh so and so's going to town but he's not going til three o'clock'. Oh well hang on, no my appointments at half past one, so that bit doesn't work." (I9)

Some interviewees were interested in informal ridesharing but hesitant to implement it because of a fear of breaking the social norm of individualized travel. As I14 explained, *"like there's a person who lives up here, who works where [name] works. But there's no [name] doesn't want to say 'Do you want to ride share', because she's willing to, and some people aren't. So it's got to come from somebody else."* The idea of social hesitation around ridesharing was also noted by another interviewee, who recognised *"I guess if it was a social norm, I'd be quite happy to take. I could do it."* (I13).

Looking to the future of ridesharing in Dunedin, different approaches might need to be used to encourage formal and informal methods, and to recognize that some will prefer one over the other. Some who were hesitant about more formal services due to travelling with strangers were more willing to travel with people familiar to them. Yet the social nervousness some people expressed about instigating their own informal networks is also a barrier. Targeted campaigns that encourage rideshare across the spectrum of formal to informal networks may help normalise ridesharing as a practice, reduce the stigma in establishing networks, and see a consequential increase in willingness.

6.6 The 'efficiency imperative'

Evident across all research conducted in the transport section of this study, was a series of dominant cultural ideals around transport. This included the importance of vehicle ownership, self sufficiency, and prioritising personal efficiency. These social norms were identified in some interviews:

"I like being free to go when and where I like." (I15)

"... most people find [ridesharing] a hassle. Because you might have to wait for someone when you want to leave early, or whatever." (I14)

"The problem with kiwis is, and this is men especially and some, some women. Is that their egos are so tied to cars. Like 'Oh look at me I drive a Holden.'" (I11)

"I just think the, the ego of people and the mindset of people in New Zealand is just way too connected to the convenience of the car." (I11)

The notion of relying on others for mobility was often cast in a negative light. For example public transport and ridesharing networks were often described as inefficient and time costly. Any schedule with slight flexibility on either side was seen as a negative, or a reason to not engage. As explained in interviews:

"Whenever I think about those the obstacle is the lack of routine and the need to commit yourself to some particular- being in a particular place at a particular time." (I15)

"... you require quite a sort of a tick tock life, that is metronomic to use these options." (I18)

"Maybe reliability. Someone has said like 'oh I'm going to this place, to this place, at this time.' And then something changes, which is fair enough, because it's like their life ... It's just easier to have that other way first." (I13)

Where priorities are for independence, efficiency and self-sufficiency, this appears to conflict with people's willingness to use sustainable transport alternatives.

6.7 Behaviour change vs technology change

One key theme which emerged in the course of this study was how interviewees differentiated between willingness to make behavioral changes and willingness to make technology changes. In terms of the energy cultures framework, that is changes in practices or changes in material culture.

The majority of households, when talking about change to achieve environmental benefits, showed a preference to change their material goods (such as buying electric vehicles, or making extensive home renovations) rather than changing behavior (such as using public transport or cycling). The importance of technology in achieving environmental ideals was particularly clear amongst electric vehicle users or aspirers. This was made explicit by one interviewee who stated that their reasoning for purchasing an electric vehicle was to reduce the need for behavioural change - *"the*

fact that we could be more sustainable, without making any significant changes to our lifestyle." This household realised that they were unlikely to transition away from using their car and made the choice to purchase electric car in order to reduce their environmental impact - *"so it's less about us adapting our behaviour and more about adapting what we're using to minimise our behaviour."* It was clear that the appeal of electric vehicles was the fact that interviewees felt as though they did not have to make compromises, or very few compromises in terms of their lifestyle and convenience - the electric car *"makes you feel better. Eases your conscience. Even though it's like, it's still a vehicle and it's not perfect. Like, the perfect way to get to- travel, is to walk. But, you know, you still want to live in society and function normally- semi normally."*

However, it is notable that some households who had acquired electric cars were also inclined towards behavioural changes. For example, one household commuted by bicycle 50% of the time, combined with their electric vehicle. Another household, who commuted by EV as their primary mode of transport, suggested that although the EV was a positive environmental step, they would still prefer to travel by public transport if this was feasible for them, despite the fact that public transport would likely be significantly more expensive than using the electric vehicle - *"because it's like, to me, the environments more important than money. And while electric cars are better than petrol, they're still not perfect. I'd rather use public transport."* (I14).

When households were asked to envision what a more sustainable transport future may look like for them, a small number mentioned lifestyle choices, e.g. how the location of their home in relation to work and education influences their ability to make positive environmental choices: *"In my case, I wouldn't live in Brighton, I'd live next to where I work, so that ... I would not be dependent on a vehicle, even electric or fuel dependent vehicle"* (I3). One interviewee suggested that their ideal of less reliance on transport was unattainable to them now, by virtue of where they had purchased their home, but that they had instead tried to pass on this value to their children: *"My children are different [to me]. They've been brought up differently and they live and work where they- they live where they work... So I think the biggest contribution I've probably made is*

that my children and my children's children have been able to take up the ethos that we would have really liked to have had ourselves" (I18).

7. Conclusion

This study has offered some insights into the attitudes and decision-making of some Dunedin households regarding their heating and transport methods. The small sample size (19 households) means that the study does not provide statistically representative data, but it does provide a range of perspectives from households across all four 'energy culture' categories and a wide demographic range. Key findings include:

1. In general, participants were aware of the environmental implications of their heating and transport choices. Many were interested in making changes (for a variety of reasons, not just environmental). Some had already made significant low-carbon changes or were planning to do so, so future policy development could build on these aspirations.
2. For the most part, households already used low-carbon forms of heating (wood fires or heat pumps) although some used scarcely any heating and thus may well have suffered health impacts.
3. Some households already made significant use of the sun for heating, and many were also interested in solar water heating and solar generation (PV). There was also interest in passive houses.
4. Although many people were interested in acquiring electric vehicles, there was concern and confusion about their environmental impacts (e.g. rare earth metals, battery disposal, use of high-GHG electricity). This appeared to be a major barrier in addition to the cost barrier.
5. At least some of the EV owners reported a 'rebound effect' – using their EVs more than they had used their previous internal combustion cars. It would be useful to see if this is more widespread.

6. Despite interest in informal shared transport (i.e. with known people) some people were hesitant because this went against the norm of individual transport, and/or were concerned about the constraints this might pose on personal flexibility.
7. Heating choices were largely driven by notions of comfort. In contrast, transport choices were largely driven by notions of independence and time-efficiency. Lower-carbon heating systems (e.g. heat pumps, wood burners) often create more comfortable homes, so maybe this is less of a cognitive barrier than changing to low-carbon transport which doesn't necessarily equate with greater time-efficiency or independence.
8. There was generally a greater willingness to make changes to material assets than changes to behavior. This is particularly interesting because material changes are usually far more costly than behavioural changes.
9. We only managed to interview one coal-using household, due to recruitment difficulties, but it would be well worth seeking to interview more. The 2018 census found that 4.2% of Dunedin households used coal as a means of heating. This equates to just over 2,000 households. Given that these households are likely to have the most difficulty in changing away from the use of coal, it would be good to carry out a further study, preferably during the winter months, that focuses on householders' view of the benefits and drawbacks, and barriers to changing to other heating methods.

This qualitative study of a small number of Dunedin households has provided some tentative insights into household behavior, decision-making and aspirations with regards heating and transport. We hope these findings are useful in their own right to help inform policy development for a low-carbon future. The findings could also inform the development of a survey of a representative sample of Dunedin's population if statistically significant results are required.

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